

## POPULATIONS OF *NEPA CINEREA* (HETEROPTERA: NEPIDAE) FROM HYPOGEAN SULFUROUS WATER IN THE LEPINI MOUNTAINS (LATIUM, CENTRAL ITALY)<sup>1</sup>

Gianluca Nardi<sup>2</sup>, Claudio Di Russo<sup>3</sup>, Leonardo Latella<sup>4</sup>

**ABSTRACT:** Hypogean populations of *Nepa cinerea* from the sulfurous water of three caves of the Lepini Mountains (Latina province, Latium, central Italy) are recorded. Continuous (1997-2000) observations of adults, all larval instars, and matings of this species in these caves exclude the possibility that their presence there is accidental. Hypogean populations of this species have not been known until now, at least in Italy. This water bug occupies the role of a top predator and probably of a scavenger in these caves. The fauna of these caves is of great conservation interest.

*Nepa cinerea* L. occurs in stagnant or slowly flowing water and is widespread in the Palaearctic Region (Polhemus et al., 1994, 1995). In Italy it has been recorded from all regions except Sardinia, where it is replaced by a related species (Tamanini, 1979; Polhemus et al., 1994).

During recent biospeleological studies a population of this species was found in the sulfurous water of a cave of the Lepini Mountains (Latina province, Latium, Italy) (Di Russo et al. 1999; Latella et al., 1999). This discovery is interesting because in Italy (cf. Servadei, 1967; Pesce, 1985) hypogean populations of the genus *Nepa* have not been known until now. Moreover, within this genus only one stygobiotic species (*N. anophthalma* Décu, Gruia, Keffer and Sarbu) is known, it being endemic in the sulfurous water of the Movile cave (Romania) (Décu et al., 1994; Sarbu et al., 1995).

### MATERIALS AND METHODS

The Lepini Mountains, approximately 40-90 km southeast of Rome, are one of the mountainous districts that constitute the southern pre-Apennines of Latium, and in total cover an area of about 80,000 hectares. They are composed mainly of Cretaceous limestone belonging to the Latium-Abruzzi carbonate platform (cf. Montecchi, 1999). The agency of water has caused an intense manifestation of karst phenomena, both epigeal (dolines, etc.) and hypogean (caves, swallow-holes, etc.) (cf. Montecchi, 1999). The cave fauna is very rich, with eleven (ten species and one subspecies) endemic troglobitic arthropods known (cf. Latella, 1995; Magrini, 1998; Latella et al., 1999). Very interesting is also the presence, in the subterranean superficial environment,

<sup>1</sup> Received May 7, 2001. Accepted August 23, 2001

<sup>2</sup> Via G. Galilei 14, I-04012 Cisterna di Latina (LT), Italy. E-mail: l\_nardi@hotmail.com

<sup>3</sup> c/o Dipartimento di Biologia Animale e dell'Uomo (Zoologia), Università di Roma "La Sapienza", Viale dell'Università, 32, I-00185 Roma, Italy. E-mail: dirussobernardini@libero.it

<sup>4</sup> Museo Civico di Storia Naturale, Lungadige Porta Vittoria, 9, I-37129 Verona, Italy. E-mail: Leonardo\_Latella@comunevr.COMUNEVR@comune.verona.it

of the monospecific endemic family Crowsoniellidae (Coleoptera: Archostemata) (cf. Lawrence and Newton, 1995).

Populations of *N. cinerea* have been found in three caves which are situated at a short distance from each other in the commune of Bassiano in the southern slope of Mount Acquapuzza. The latter is composed of Cretaceous light-brown limestone with dolomitic alternation (Piro 2000):

1) Cave without register number near the "Grotta di Fiume Coperto". This little cave (maximum height 4-5 m, length 10 m approximately) has two entrances (one at ground level, at 20 m a.s.l., the other on the ceiling) and only one room with earthen ground, which slopes to a large sulfurous pool with overhanging stalactites. This pool has a variable width and depth and is very probably connected with the water system of Cave 2, below. *Proasellus coxalis* (Dollfus) (Crustacea, Isopoda, Asellidae) and *Niphargus stefanellii* Ruffo and Vigna Taglianti (Crustacea, Amphipoda, Niphargidae) also have been found in the water.

2) "Grotta di Fiume Coperto" (La1361). The cave opens at 21 m a.s.l., approximately 30 m "downstream" from Cave 1, above, has a horizontal structure and is 170 m long. A small entrance leads, after a few meters, into the main gallery where there is a very slow flowing stream. The water forms a series of small pools which differ in width and depth. The last one, located in the terminal part of the cave, ends in a siphon. Most of the cave's water is likely to be drained by the numerous sulphurous springs next to the cave entrance. The mean temperature of the cave's water is  $14.4 \pm 0.5$  °C; its most important physicochemical parameter is the high level of hydrogen sulfide (7 mg/l) which allows for the development of sulfide-oxidising and methano micro-organisms (Di Russo et al., 1999; Latella et al., 1999). The aquatic fauna is very rich: besides the above-said Crustaceans, there are many Protozoa, Colurellidae indet. (Rotifera, Monogononta), *Islamia* sp. (Gastropoda, Neotaenioglossa, Hydrobiidae), *Dina lineata* (O. F. Müller) (Hirudinea, Arhynchobdellae, Erpobdellidae) and three species of Cyclopidae (Crustacea, Copepoda) (Latella et al., 1999).

3) "Grotta della Cava" (La384). This cave opens at 30 m a.s.l., approximately 180 m southeast from Cave 2, above, from which it is largely separated by a derelict quarry. It includes rooms with different characteristics: near the entrance (an almost horizontal narrow cleft) there are rocks and landslide debris, other rooms have active stalactites and some are periodically flooded as indicated by water impressions on the walls and by typical cracks on thick strata of mud. *Nepa cinerea* has been collected here in association with *Islamia* sp., Hirudinea and Isopoda unidentified.

The above sulfurous springs underlying these caves are of strong biological interest (Rivosecchi et al., 1975; Nardi, 1994) and are also the type locality of *Simulium pontinum* Rivosecchi (Diptera, Simuliidae), a species endemic to

central Italy, and one of the few of this family with immature stages living in very sulfurous water (cf. Rivoecchi, 1960; Nardi, 1994).

During surveys of these caves, observations on water scorpions were recorded (Table 1) and some specimens were collected. Most observations pertain to Cave 2, which has been studied for longer periods because of its notable biospeleological interest (Di Russo et al., 1999; Latella et al., 1999). Some adults and larvae were placed in a plastic aquarium (18x9x6 cm) in the dark to study their behavior. The morphological study of the sampled specimens (preserved in authors' collections) has shown that they fall within the range of variation of the species (Mazza, 1975; Polhemus et al., 1994).

### RESULTS AND DISCUSSION

In the three caves described above, *N. cinerea* has been observed (Table 1) in almost all months of the year. The observations of all larval instars, of ecdyses, of remains of dead specimens and of matings exclude the possibility that the presence of this species in caves is accidental, temporary or caused by drift. In Cave 2, *N. cinerea* has been observed along almost all of the length of the stream, including its terminal part at approximately 170 m from the cave entrance. Our surveys have been carried out in the caves in a heterogeneous manner (duration, number of participants and time dedicated to the water community), so quantitative information on the dimensions of the populations is

Table 1. Observations of *Nepa cinerea* in the caves of the Lepini Mountains.<sup>1</sup>

Date	Cave 1	Cave 2	Cave 3
07/22/97	0	A	-
08/16/97	L	0	-
09/27/97	-	A	d
11/6/97	-	A L M	-
11/16/97	-	A	d Ar Lr
02/11/98	-	A	-
03/30/98	-	A L	-
04/9/98	A	A M	-
10/12/98	-	A L	-
10/17/98	A	A L	-
11/28/98	-	A	-
12/29/98	-	A	-
07/18/99	-	A	-
12/28/99	-	-	A L M
03/12/00	A	A L	d
11/12/00	A L	-	-
12/20/00	A L	A L	d Ar

<sup>1</sup>Abbreviations: A = adults; Ar = remains of adults; d = dried pools; L = larvae; Lr = remains of larvae; M = matings; - = cave not visited; 0 = no observations.

unavailable. In any case, in Cave 2 an average of 8 specimens (adults or adults and larvae) per visit have been observed. Matings were observed in April, November and December, and very young larvae, at least, in October and November; according to Tamanini (1979: 48 [translation from Italian]) in epigeal water the egg-laying "starting in April-May, according to the regions. There is only one generation per year also in the warm regions". Our observations seem to suggest that the hypogean populations have a broader reproductive period; a similar behavior was also observed in captivity by Mazza (1975).

Only a few observations (Table 1) are available for Cave 3 due to the temporary nature of its aquatic habitats. Remains of an adult and of a mature larvae were collected in a large pool as soon as it dried up (11/16/1997); some adults (two in mating) and larvae were found (12/28/1999) in a large residual pool (20 cm deep) with transparent sulfurous water; subsequently (12/20/2000) the remains of an adult were found under a stratum of mud in a dried pool. These observations suggest that during the dry periods in this cave this species probably survives in the egg stage or takes refuge following the variations of the water level in the microfractures and/or under the thick strata of mud. Here, at least adults (some in captivity survived for two months until starvation) evidently survive consuming reserve food energy (cf. Waitzbauer, 1978, as *N. rubra* L.).

The species is a polyphagous carnivore (Tamanini, 1979), and in these caves very likely feeds on numerous syntopic Crustaceans; Asellidae (Crustacea, Isopoda), for example, are its usual prey (Mazza, 1975). In captivity an adult coming from Cave 1 preyed on a *Niphargus stefanellii*, and an adult coming from Cave 3 preyed on a conspecific larva, some *Islamia* sp. and probably also an unidentified Hirudinea. Moreover, in captivity a larva coming from Cave 2 was observed to feed on a dead specimen of *Dolichopoda geniculata* (Costa) (Orthoptera, Raphidophoridae) previously found in a pool of the same cave. These observations suggest that *N. cinerea* occupies the role of a top predator and probably of a scavenger in these caves.

On several occasions the ability of some captive adults to fly was assessed by allowing the water of the aquarium containing them to evaporate naturally. However the adults, despite having normal wings, never flew even if completely without water; rather, they hid in the mud.

This species is widespread in the epigeal water of the Lepini Mountains district (Nardi, 1994). It has also been collected in the sulfurous water springs underlying Cave 2 (Di Russo and Nardi unpubl.), in the cold sulfurous water of the nearby Vescovo Lakes (Pontinia, Latina, 3 m a.s.l.) and at Monticchio (Sermoneta, Latina, 15 m a.s.l.) in fresh water that mixes with cold sulfurous water (Nardi unpubl.). The species in Latium also is frequently found in the sulfurous water of the Caldara di Manziana, Rome (Nardi, 1994) and in the sulfurous warm waters of Bagni di Tivoli, Rome (Issel, 1901a, 1901b; Wagner,

1958, as *N. sardiniensis* Hungerford [misidentification]). This peculiar feature of its ecology probably facilitated the colonization of the sulfurous water of the Lepini Mountain caves. The specimens coming from these caves are often covered with a whitish patina of sulfur (Di Russo et al., 1999 fig. 5) and with reddish incrustations.

Considering the morphology of the entrances of the caves described above and the reluctant flying attitude of the species (Mazza, 1975; Tamanini, 1979), the hypogean colonization has probably occurred by larvae and/or adults that immigrated (cf. Mazza, 1975; Waitzbauer, 1978) into the caves from the underlying epigeal springs, perhaps during strong reductions or disappearances of their water flow such as have been observed during the last twenty years (Rivosecchi et al., 1975; Piro, 2000; Nardi unpubl.). The environmental stability, scarcity of competitors, abundance of prey, and the ecological tolerance to sulphur of this species probably played a fundamental role in allowing a lasting colonization of this subterranean environment.

#### ACKNOWLEDGMENTS

We are indebted to C. Belluzzo (Museo Civico di Storia Naturale, Verona, Italy), C. Esposito (Cisterna di Latina, Italy), M. Mei (Università di Roma "La Sapienza", Italy), A. Nardi (Cisterna di Latina, Italy), M. Rampini (Università di Roma "La Sapienza", Italy), S. Ruffo (Museo Civico di Storia Naturale, Verona, Italy), J. C. Tyler (Smithsonian Institution, Washington D.C., U.S.A.), and A. Vigna Taglianti (Università di Roma "La Sapienza", Italy) who assisted us in various ways during the preparation of this paper. We also thank two anonymous referees for their constructive suggestions on this manuscript.

#### LITERATURE CITED

- Décu, V., M. Gruia, S. L. Keffer and S. M. Sarbu. 1994. Stygobiotic Waterscorpion, *Nepa anophthalma*, n. sp. (Heteroptera: Nepidae), from a Sulfurous Cave in Romania. *Ann. Entomol. Soc. Am.* 87: 755-761.
- Di Russo, C., L. Latella and M. Rampini. 1999. La Grotta del Fiume Coperto e il suo significato biologico (Italia Centrale - Lazio). *Speleologia* 41: 57-60.
- Issel, R. 1901a. Saggio sulla fauna termale italiana. Nota I. *Atti Accad. R. Sci. Torino* 36 (1900-1901): 53-72.
- Issel, R. 1901b. Saggio sulla fauna termale italiana. Nota II. *Atti Accad. R. Sci. Torino* 36 (1900-1901): 3-15 [reprint].
- Latella, L. 1995. La fauna cavernicola dei Monti Lepini. *Not. Circ. Speleol. Romano* 6-7 (1991-1992): 77-119.
- Latella, L., C. Di Russo, L. De Pasquale, L. Dell'Anna, G. Nardi and M. Rampini. 1999. Preliminary investigations on a new sulfurous cave in central Italy. *Mem. Biospéologie* 26: 131-135.
- Lawrence, J. and A. F. Newton, Jr. 1995. Families and Subfamilies of Coleoptera (with selected genera, notes, references and data on family-group names): 779-1006. In: J. Pakaluk and S. A. Ślipiński (eds.), *Biology, Phylogeny, and Classification of Coleoptera: Papers celebrating the 80th birthday of Roy A. Crowson*. Volume 2. *Museum i Instytut Zoologii PAN, Warszawa*.
- Magrini, P. 1998. Diagnose préliminaire de deux nouveaux *Duvalius* (s.str.) du Latium (Coleoptera, Carabidae, Trechinae). *Les Comptes-rendus du L.E.F.H.E.* 1998 (3): 151-159.
- Mazza, M. 1975. Variabilità ed anomalie negli scorpioni d'acqua euromediterranei (Heteroptera Nepidae). *Atti Soc. Tosc. Sci. Nat., Mem., Serie B*, 81 (1974): 209-247, 1 pl.

- Montecchi, G.** (ed.). 1999. I Monti Lepini. Un territorio segnato dal carsismo. Provincia di Roma - Assessorato all'Ambiente. Quaderni dell'Ambiente 2: 96 pp.
- Nardi, G.** 1994. Note preliminari sull'entomofauna acquatica dei Monti Lepini (Lazio) (Ephemeroptera, Odonata, Plecoptera, Heteroptera, Coleoptera, Trichoptera): 7-91, 4 pls. In: L. Corsetti and G. Nardi (eds.), Ricerche sulla Fauna dei Monti Lepini. Quad. Mus. St. Nat. Patrica 4. (1993).
- Pesce, G. L.** 1985. The groundwater fauna of Italy: a synthesis. *Stygologia* 1(2): 129-159.
- Piro, M.** 2000. La Grotta di Fiume Coperto. *Speleologia del Lazio* 1: 17-20.
- Polhemus, J. T., A. Jansson and E. Kanyukova.** 1995. *Nepomorpha*: 13-76. In: B. Aukema and C. Rieger (eds.), Catalogue of Palaearctic Heteroptera. 1. The Netherlands Entomol. Soc., Amsterdam.
- Polhemus, J. T., N. Nieser and S. L. Keffer.** 1994. Synonymical notes on the *Nepa cinerea* Linnaeus complex (Nepidae: Heteroptera). *Tijdschr. Entomol.* 137: 331-336.
- Rivosecchi, L.** 1960. Un nuovo Simulide dell'Agro Pontino. *Riv. Parassit.* 21: 229-244.
- Rivosecchi, L., G. Dojmi Di Delupis, M. Noccioli and L. Rubeca.** 1975. Stato di conservazione delle sorgenti pedemontane dell'Agro Pontino e anofelismo residuo. *Atti V Simp. Naz. Conserv. Natura*, Cacucci ed., Bari, 2: 119-142.
- Sarbu, S. M., T. C. Kane and B. K. Kinkle.** 1995. A chemoautotrophically based cave ecosystem. *Science* 272: 1953-1955.
- Servadei, A.** 1967. Fauna d'Italia. IX. Rhynchota (Heteroptera - Homoptera Auchenorrhyncha) Catalogo topografico e sinonimico. Ed. Calderini, Bologna. X, 854 pp.
- Tamanini, L.** 1979. Guide per il Riconoscimento delle specie animali delle acque interne Italiane. 6. Eterotteri Acquatici (Heteroptera: Gerromorpha, Nepomorpha). Consiglio Nazionale delle Ricerche AQ/1/45, Roma. 108 pp.
- Wagner, E.** 1958. Nachtrag zur Hemipterenfauna Siziliens (Heter.). *Boll. Soc. entomol. ital.* 88: 139-142.
- Waitzbauer, W.** 1978. Studies in energetics and population dynamics of the Water Scorpion, *Nepa rubra* L. (Insecta: Hemiptera). *Oecologia* 33(2): 235-253.